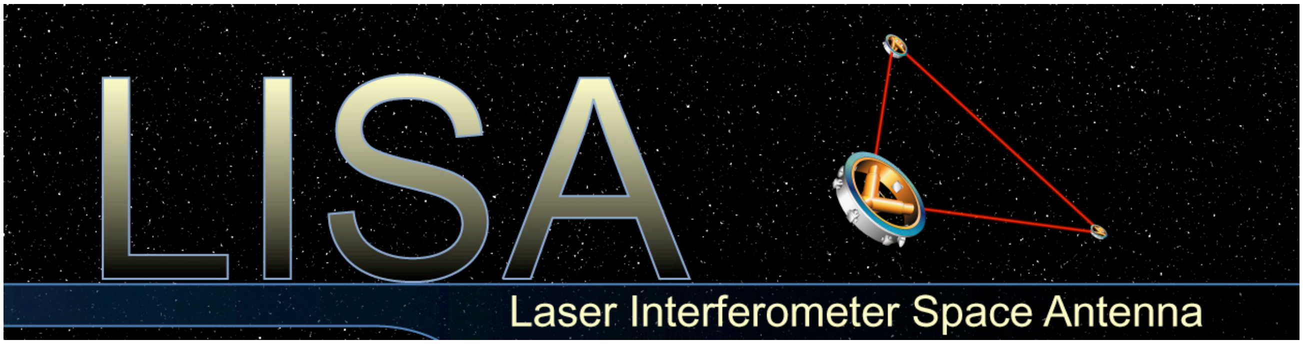

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Welcome to the LISA newsletter

This is the first edition of the LISA newsletter which is intended to help keep us up to date with the latest project developments. The aim is to produce this 3-4 times a year and to include technological and scientific articles and profiles of personnel involved in the project. There will also be notices of upcoming conferences and reviews of recent meetings.

In this edition we have reports from the 9th LISA science and engineering meeting held in Pasadena from 22nd – 26th March 2004 and an interview with Karsten Danzmann, the ESA mission scientist for LISA.

If you would like to contribute to future issues please contact

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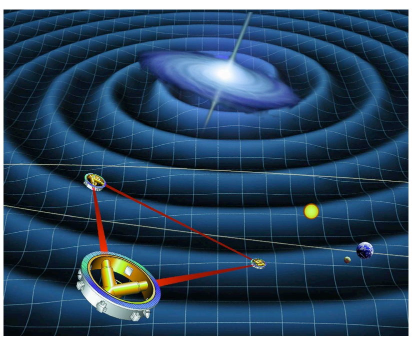
Introduction to the LISA mission



Artists impression of the LISA mission, bathed in gravitational waves emitted from a distant cosmic event

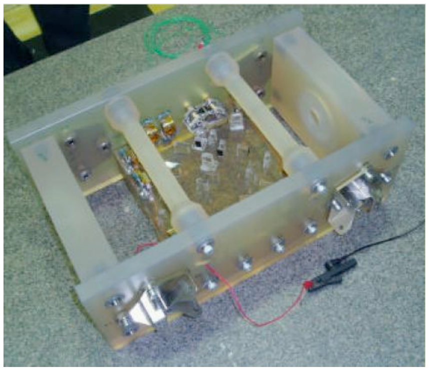
Gravitational waves are ripples in the fabric of spacetime, caused by the acceleration of masses in space. They were predicted by Einstein's theory of general relativity but have not yet been detected directly. New facilities are being built to study them. Earth-based gravitational wave detectors, such as the Laser Interferometer Gravitational Wave Observatory (LIGO) are designed to detect the higher-frequency gravitational waves resulting from transient phenomena such as supernovae. The most violent events in the Universe e.g. mergers of supermassive black holes produce gravitational waves at lower frequencies which cannot be detected on Earth due to interference from the Earth's own shifting gravitational field. To detect these events we require a space-based instrument.

The Laser Interferometer Space Antenna (LISA) will be the first dedicated space-based gravitational wave observatory. It is a joint NASA/ESA mission and it will measure the distortions in spacetime caused by the most violent events in the Universe. It will study the coalescence of supermassive black holes in the centers of galaxies, massive black holes capturing compact objects and binary compact objects in our own Galaxy. LISA and its ground-based counterparts will be able to explore the fundamental nature of gravity and open a new window on the Universe.

LISA consists of three identical freely flying spacecraft in an equilateral triangle formation, with each arm of the triangle being five million kilometers long. LISA detects gravitational waves by measuring the change in distance between freely floating test masses in each of the spacecraft. These test masses ideally are isolated from all forces other than gravity. The changes in distance can be measured using laser interferometry. Using this technique, LISA will study the sources of gravitational waves and so reveal a Universe we have never before been able to detect.

Report from the 9th LISA Science and Engineering workshop

Project status update



Optical bench and interferometer for the LISA Technology Package on LISA Pathfinder

During the 9th LISA Science and Engineering workshop, held from 22nd – 26th March in Pasadena, **Bryant Cramer** (NASA/Goddard) and **Alberto Gianolio**, (ESA), the US and European project managers respectively, gave summaries of the project status. From the US perspective, budget reductions over the next two years mean that some early project milestones will be delayed, possibly by up to a year. In order to accommodate these budget constraints and to minimize the impact on the project in the long term, some re-planning of the technological development is underway. The intention is to concentrate on strategically important technology and those technologies that require time to develop.

On the European side, LISA has been formally started at ESA with the appointment of Alberto Gianolio as project manager and Marcello Sallusti as the system engineer. The LISA Pathfinder payload and project managers (Cesar Garcia and Giuseppe Racca) have also been selected.

There have been several important technological developments. The caging system developed by Rutherford Appleton Laboratory (RAL) in England has recently been delivered to Carlo Gavazzi Space (CGS) for integration and testing with the inertial sensor. Tests of the optical bench have also started and the tilt and calibration results are well within expectations.

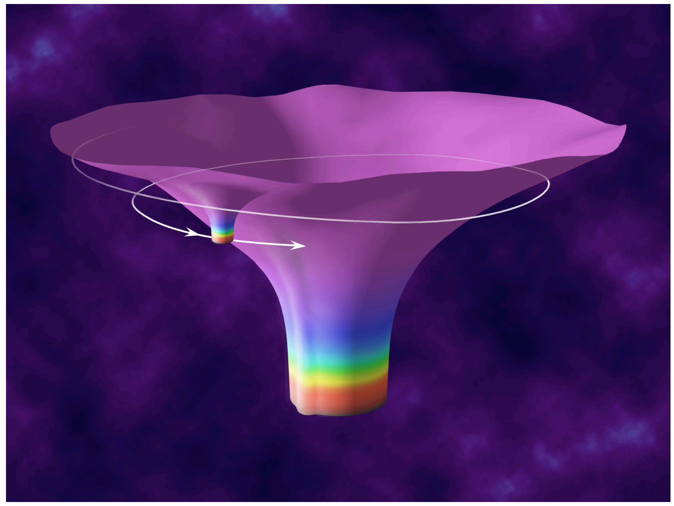
In the immediate future, work is required on the structure of the US project organization and agreement is needed on the mission formulation objectives, milestones and reviews.

Mission Science update

Karsten Danzmann (Hanover) began the report for the science team and focused on the issues of data analysis. Even though the mission is still several years from launch it is important to be investigating and developing plans for analysis of LISA data at this stage, since the success of the mission ultimately depends on this being done well. LISA data analysis is likely to be significantly more complex than for ground-based gravitational wave detectors such as LIGO or GEO because the strong signal-to-noise ratios and source confusion complicate matters. (The strong signals from supermassive blackholes will need to be removed before weaker signals can be detected.) Source signals will be obtained from the data stream by matched filtering – a process whereby known signals can be detected and extracted as components of a more complicated signal. Because LISA will detect gravitational waves from many different sources and from many different directions simultaneously, several tasks will need to be undertaken at the same time and several iterations will probably be needed before solutions converge. The solutions will need to be further refined as new data become available. Since the approach to the data analysis can affect the design of the payload it is important that these issues are addressed early on in the project's life.

Science Team Update (*cont*)

Tom Prince (Caltech/JPL) reported on progress made by the LISA international science team in several areas, in particular in the study of extreme mass ratio inspirals (EMRIs - sources where a few solar mass black hole is falling into a massive (10^6 solar mass) black hole. The requirements for the detection of these events drive some important technical requirements for LISA e.g. laser power, mirror diameter. Recent estimates of event rates have led to the conclusion that the baseline sensitivity of LISA is sufficient to detect several EMRI events per year. This work has been published by Barack & Cutler (2004) gr-qc/0310125 and Barack et al. (2003) Report of LISA Working Group 1, (www.srl.caltech.edu/lisa/lm.html).



The warping of space-time caused by an extreme mass ratio inspiral source (Kip Thorne/Caltech)

Another achievement has been the development of the "Synthetic LISA" simulator by Vallisneri and Armstrong (NASA/JPL). This model simulates the LISA fundamental noises and gravitational wave response at the level of the science/technical requirements. It can be used to investigate alternative detector configurations and for interfacing scientific and technical requirements. It will be released as open software by 5/31/04.

Other work carried out by the science team included studies of interferometric techniques including arm-locking and time-delay interferometry, and the extension of the science requirements at high and low frequencies.

Upcoming events

American Physical Society meeting (1st – 4th) May, Denver

Beyond Einstein: From the Big Bang to Black Holes (12th – 15th May 2004) Menlo Park, California

Astrophysical Frontiers: Instruments for the 21st Century (18th – 21st May) Berlin

Making Waves with Black Holes (20th – 24th May) Penn State

204th meeting of the American Astronomical Society (31st May - 3rd June) Denver.

Growing Black Holes (21st – 25th June) Garching

LISA science team meeting (15th - 16th July 2004) at ESTEC

5th International LISA symposium (12th – 16th July 2004) at ESTEC

35th COSPAR Assembly (18th – 21st July 2004), Paris

17th International Conference on General Relativity and Gravitation (18th – 24th July 2004) Dublin, Ireland

Meet a scientist – Karsten Danzmann

Karsten Danzmann is a director at the Max-Planck Institute for Gravitational Physics and professor of physics at the University of Hannover. He is also the European co-chair of the LISA International Science Team. His interest in astronomy started at a young age, when he pestered his parents for a telescope and spent many nights looking at the stars. He tells us more about what got him interested in science and what is his involvement in the LISA mission.

One of the most important moments for stoking my interest in space was the landing on the moon. I remember clearly that it was 3am in Germany and I was glued to the tv watching and then I knew – this is something I want to do. I was also inspired by a series of tv lectures given by Herman Bondi. I was absolutely fascinated and a few years ago I met him and told him he was responsible for me being in relativity and related things and he said 'Well it's good to hear that my show was at least good for something'.

I've been with the LISA project for over 10 years. I was a member of the team that initially proposed the LISA project proper. That's when the name first appeared but of course the idea of a space-based interferometer is a lot older.

As for what we hope to learn from LISA, it is always difficult to say exactly what we don't know yet. The most interesting things will be the ones that we have no hope of knowing or predicting right now. But there is one thing we hope we will find out about - the dark side of the Universe. Most of what we know about the Universe comes from electromagnetic radiation but most of the Universe does not emit this type of radiation – it is dark. This part of the Universe is not made of matter as we know it, but we do know that it interacts with gravity so gravitational waves may give us a chance to learn about it.

The most exciting thing about this project is the chance to learn about something that we can find out about in no other way. And we may even have a chance to look down the throat of the Big Bang. We know that the Universe was opaque, not transparent, to light during the first 380,000 years, so with light we will never have a chance to see the beginning of it all. Now for gravitational waves that is different, because the Universe has been transparent for gravitational waves from the very beginning. If we are ever going to see how it all began, then gravitational waves are probably our only chance.

For more information

See

lisa.nasa.gov

sci.esa.int/home/lisa

Mission partners

LISA is a joint NASA/ESA mission. It is part of the Beyond Einstein program: a pursuit of the Structure and Evolution of the Universe theme within the office of the National Aeronautics and Space Administration (NASA).